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EM-TR-76087

THE ECONOMICS OF APPLYING SUPPRESSIVE SHIELDING TO THE M483A1 IMPROVED CONVENTICNAL MUNITION LOADING, ASSEMBLING, AND PACKING FACILITY

by

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Manufacturing Technology Directorate

January 1977

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An entirely new facility to produce the 155-mm M483A1 improved conventional munition is being planned. This report describes the proposed processes and design layouts for the plant and develops new layouts using the benefits of suppressive shield technology. Cost analyses are performed which indicate that suppressive shielding layouts not only meet all production and safety requirements but they are also the most cost effective design. Savings from the use of suppressive shielding are estimated at $4,591,309.

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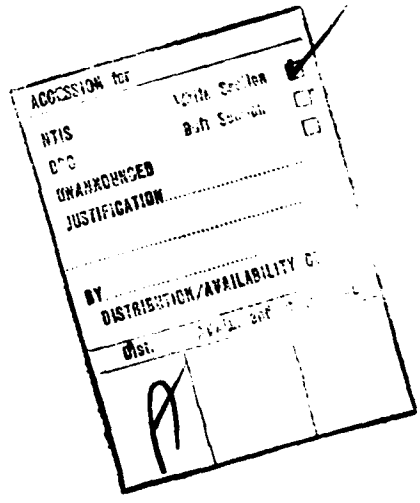
PREFACE

The work described in this interim report was authorized under MMT Project 5761264, Advanced Technology for Suppressive Shielding of Hazardous Production and Supply Operations. This work was started in 1973 and is continuing.



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THE ECONOMICS OF APPLYING SUPPRESSIVE SHIELDING TO THE M483A1 IMPROVED CONVENTIONAL MUNITION LOADING, ASSEMBLING, AND PACKING FACILITY

I. INTRODUCTION.

The purpose of this study is to evaluate proposed layouts for the loading, assembling, and packing of improved conventional munitions (ICM) and develop alternative layouts using suppressive shielding technology around hazardous explosive operations. The goal is to determine the most economic facility that will meet production requirements both for peak production and for guaranteed production in case of an accidental detonation. Insurance of a safe environment in the facility is also desirable.

Proposed layouts for the M483A1 ICM loading, assembling, and packing facility were developed by Picatinny Arsenal engineers[1] and evaluated by Kaiser engineers[2] for the US Army Corps of Engineers, Huntsville, Alabama. Data from these analyses are used in this report to determine layout concepts of the proposed facility and to determine costs of various alternatives and are assumed to be correct.

This report is divided into five sections. The first section briefly describes the processes for loading, assembling, and packing of ICM's and the layout alternatives proposed by Picatinny Arsenal. Section II deals with various facility layouts using suppressive shielding technology. Section III lists the benefits, the cost savings and tradeoffs, and the safety comparisons of the Picatinny Arsenal layouts versus the suppressive shielding layouts. Sections IV and V give conclusions and recommendations, respectively.

II. 155-MM M483A1 INTEGRATED IMPROVED CONVENTIONAL MUNITION FACILITY PROCESSES, DESCRIPTIONS, AND PROPOSED LAYOUTS.

The integrated ICM facility, in its conception, was to manufacture all metal parts and to load, assemble, and pack the M483A1 projectile at a monthly production rate of 120,000 units on a 500-hour basis. The facility encompasses all support and storage buildings, utilities, process equipment, ancillary equipment, ramps, walkways, and material handling equipment. Only the loading, assembling, and packing area is considered in this report.

The M483A1 projectile is a 155-mm round with a payload of 88 shaped-charge M42/M46 grenades. These grenades are expelled from the projectile in flight by an M10 propellant expelling charge, scattering them over a large area. Each grenade contains a 31-gram shaped charge of A-5 explosive and functions as both an antipersonnel and an antimateriel device. The grenades are cylindrical (1.25 inch in diameter and 1.5 inch high) with a fuze extending from one end and a brass cone inserted into the other to form the shaped charge.

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[1] Picatinny Arsenal, Dover, New Jersey. Draft Design Criteria; Load, Assemble, and Pack Facility for Projectile, 155-mm: HE, M483A1. October 1975.

[2] Kaiser Engineers. Report No. 76-19-RE. 155-mm M483 ICM Complex: Load, Assembly, and Pack Facility Alternatives Evaluation. Prepared for US Army Corps of Engineers. February 1976.

The following explosive-handling processes occur in the loading, assembling, and packing area, inert handling being omitted. (Figure 1 is a schematic of the facility layout.) A-5 explosive is received by truck in 60-pound fiber drums in a separate receiving building. These drums are opened by hand and emptied into a machine which in turn places 25 pounds of A-5 explosive on an enclosed flanged belt conveyer. Explosive in the receiving building is limited to 10,000 pounds.

The explosive is moved by this conveyer to a screening building (or buildings) where dual screening takes place to insure proper grain size. The screening building is a totally remote operation controlled from the receiving building. The screening building has a 1,000-pound limit if one building is used or a 500-pound limit if two buildings are used. In either case, it is a Category III (critical) hazard (MIL-STD-882).

The screened explosive is moved in buckets in 15-pound increments by an overhead trolley conveyor to the loading, assembling, and packing buildings. The first operation in the loading, assembling, and packing building is a surge and inspection hold for the screened A-5 explosive with a limit of 2,000 pounds if one loading, assembling, and packing building is used or 1,000 pounds if two loading, assembling, and packing buildings are used. A reinforced concrete wall will be used to protect this explosive from any detonation that may occur elsewhere in the loading, assembling, and packing building.

After acceptance by quality control, the explosive is automatically moved to the grenade loading area (Category III hazard) and dumped into the hopper of a press loading machine (38-pound limit). This machine presses the A-5 explosive into the grenade to a predetermined level. The grenades are then moved to a separate bay (15-pound limit) where a brass cone is swaged into the base of the grenade to make it a shaped charge (Category III, hazard). A 5-ton press is used to assure that no air gap exists between the cone and the explosive. Six each of the grenade load and swage stations are needed to meet production requirements.

The loaded grenades are assembled onto trays (48 per tray) and 64 trays are placed on a cart (206-pound net explosive). These carts are moved by driverless tractor to an 8-hour hold in a nearby building while quality checks take place. Upon acceptance, the carts are returned to the loading, assembling, and packing building for fuze assembly.

Fuzes are attached to the grenade by a large (approximately 16-foot by 16-foot) machine that completes the entire fuzing operation. An 8-pound explosive limit has been established for each of the 20 machines needed for this operation. After fuzes have been attached, the grenades are once more loaded onto carts and moved by driverless tractor to a 40-hour hold for quality assurance inspection. After inspection, the grenades are returned to the loading, assembling, and packing building for continued processing.

The next operation is the loading of the grenades into the 155-mm projectile. The round is placed nose down in a fixture, with a flat-topped hydraulic ram inserted up into the round. A layer of eight grenades, held in position by a plastic spacer, is loaded into the base of the round. The ram is lowered one notch and a second layer of grenades is inserted, the fuzes of the second layer fitting into the cone-shaped charge of the first. Eleven layers are added in this way with a twelfth spacer layer being added. A base plate closes the base of the round.

The expulsion charge, a 51-gram bag of M10 propellant prepared in a separate building, is now inserted into an expulsion cup placed in the nose of the projectile. A lifting plug is threaded into the nose of the projectile and the projectile is marked, palletized, and shipped out.

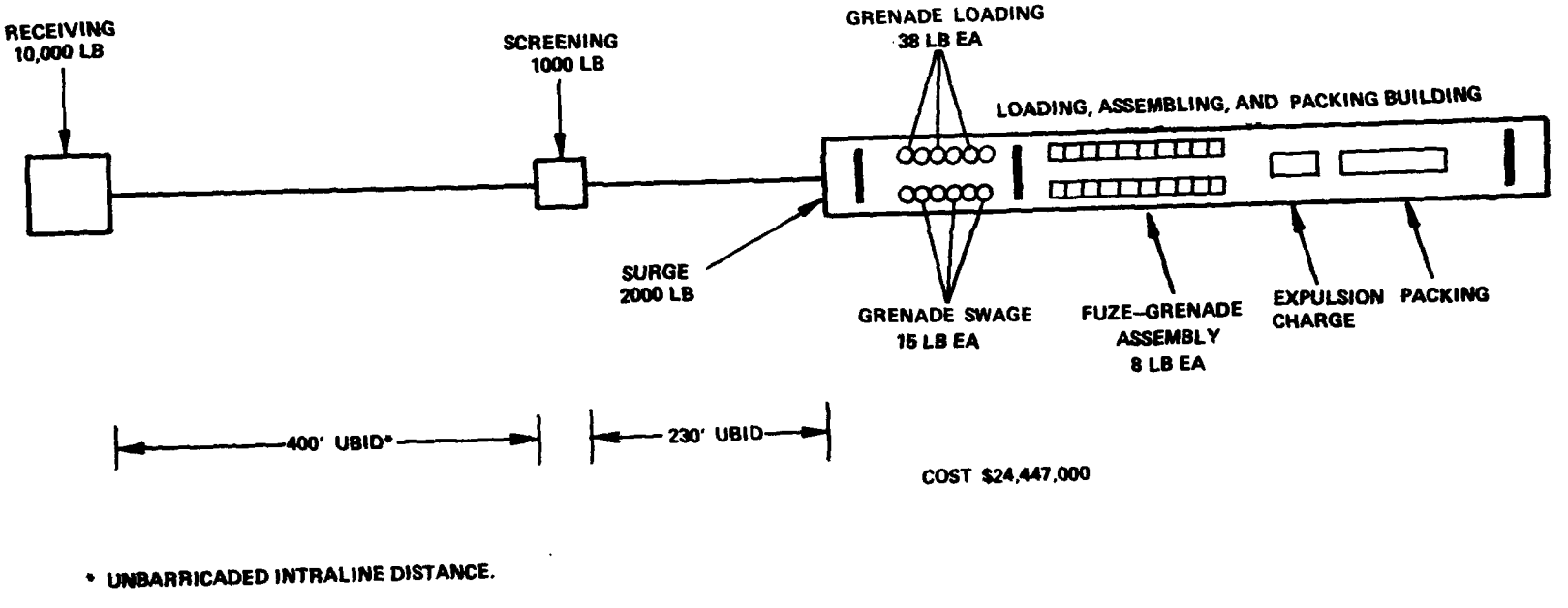

Figure 1. Current One-Building Design

Three areas in the loading, assembling, and packing building as conceived by Picatinny Arsenal engineers were shielded by TM 5-1300-type walls. The grenade loading and swaging cubicles are 15 by 16 by 10 feet and 10 by 16 by 10 feet, respectively. These cubicles are shielded by concrete walls on three sides and the roof, the fourth side being open to a frangible outer wall. The fuze-to-grenade cubicle (20 by 20 by 10 feet) has all four walls of concrete which continues as steel up to a frangible roof. In addition, TM 5-1300-type walls separate various portions of the loading, assembling, and packing building so that an incident in one area has less severe effects in the next area. Distances between buildings as specified in AMC Regulation 385-100 are sufficient to prevent major damage in case of an explosion.

Three layout designs were established by Picatinny Arsenal for further evaluation. The first, a one-building design shown in figure 1, has the advantage of being the lowest cost design ($24,449,000). Figure 2 shows a two-building layout which is the most expensive design ($27,987,000) but guarantees 50 percent production capability while repairs are occurring from an accidental detonation anywhere in the facility. This layout merely separates the one-building layout into two mirror image lines with half the production occurring on each. The three-building layout, shown in figure 3, costs $25,768,000 and will suffer less damage from an explosion than the one-building layout. The three-building layout separates the loading, assembling, and packing building of the one-building design into three loading, assembling, and packing buildings, one each for grenade load and swaging, fuze-to-ground assembly, and projectile cargo loading. Thus an incident in one building initiates little damage in the other two. Production is stopped in the event of an explosion. Cost estimates for each layout as developed for the Corps of Engineers, Huntsville, by Kaiser Engineers are presented in appendix A.

III. LAYOUTS USING SUPPRESSIVE SHIELDING TECHNOLOGY.

All locations where explosives are handled in the loading, assembling, and packing portion of the facility were investigated as potential areas for suppressive shielding applications. All but four were eliminated because they involved very large quantities of explosives or because the probability of an incident was extremely low. The four locations investigated in depth were the screening operation, the grenade loading area, the grenade swaging area, and the fuze-to-grenade assembly area.

In performing the analysis of the facility layouts using suppressive shields, it was assumed that the design was required to guarantee 50 percent production in case of an accident at the lowest initial cost possible. The two-building layout must therefore be used as this is the only design guaranteeing 50 percent production.

Along with the principle that 50 percent production must be maintained, two screening buildings, each having an explosive limit of 500 pounds and performing half the work, would be necessary. The most cost effective shield to perform this function would be a scaled-up version of the shield shown in figure 4. This shield would be cylindrical, having vertical interlocked I-beam walls as shown in figure 5, and laced, reinforced concrete roof and foundation. The shield dimensions would be approximately 32 feet in diameter by approximately 31 feet high. This shield would completely contain all fragments and would reduce pressures outside so that 3.5 psi (equivalent intraline distance pressure) would occur about 6 feet from the shield. This shield is estimated to cost $439,830 and it would replace the entire screening building. Detailed cost estimates for suppressive shields are located in appendix B.

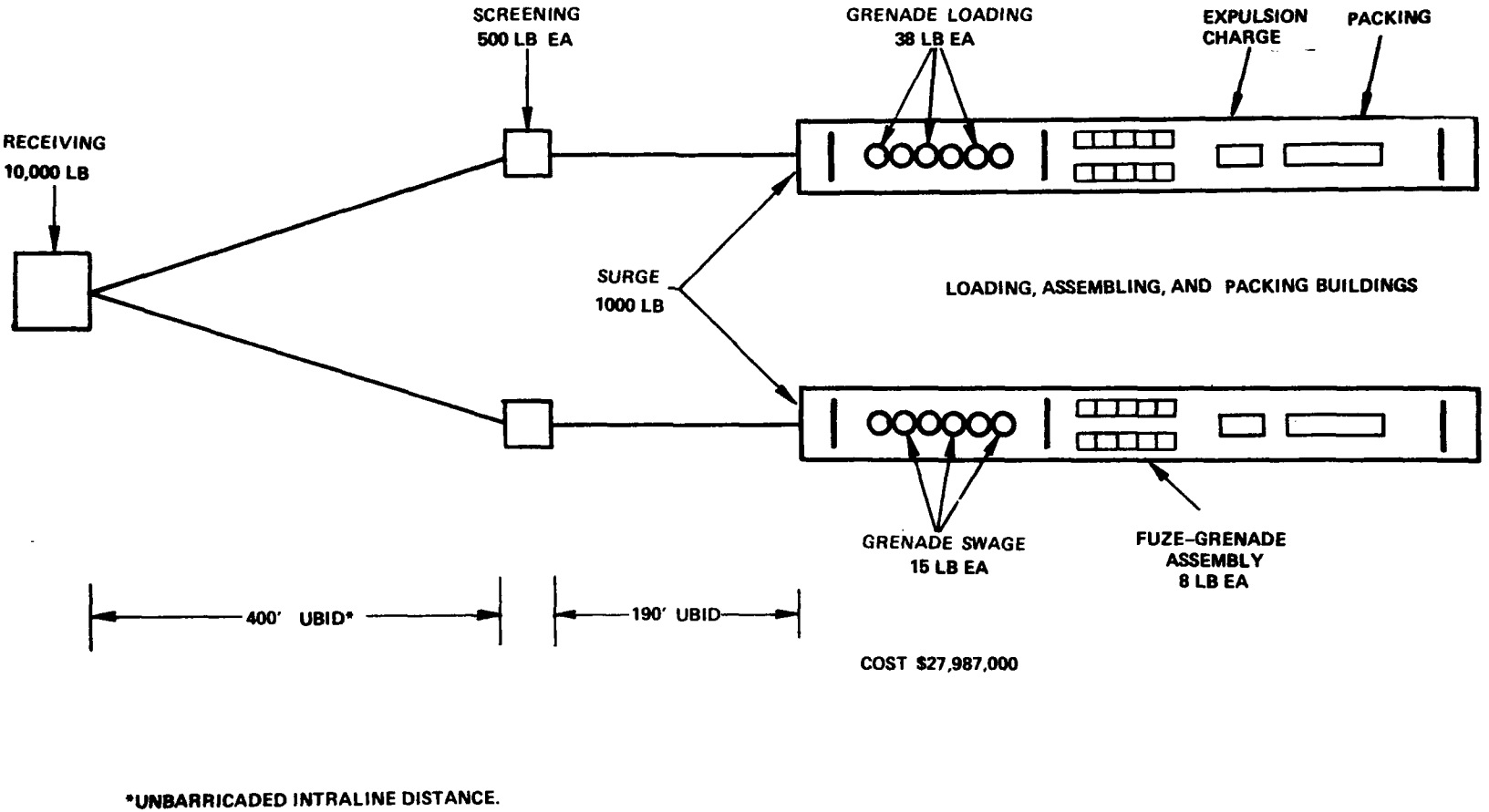

Figure 2. Current Two-Building Design

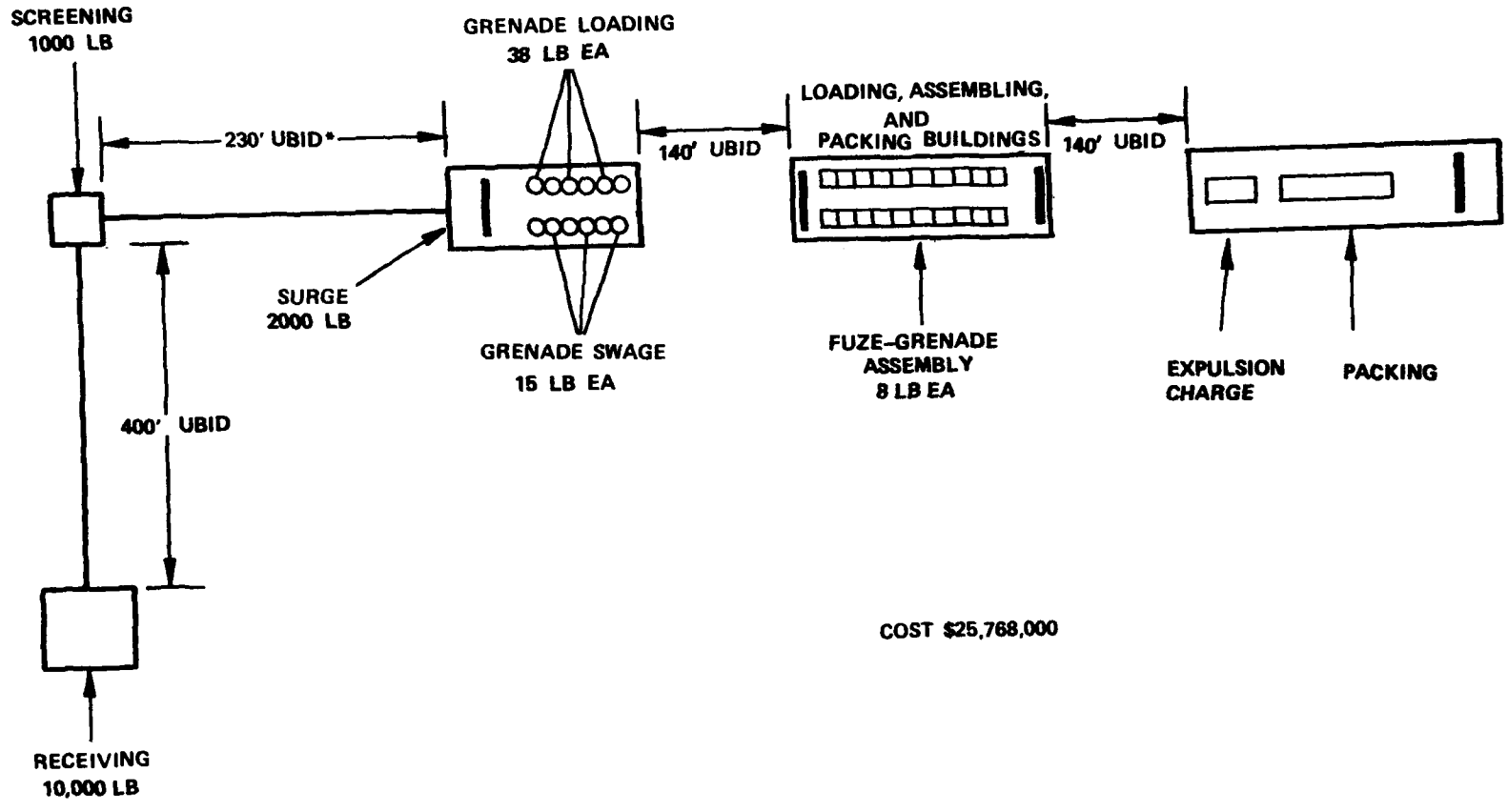

Figure 3. Current Three-Building Design

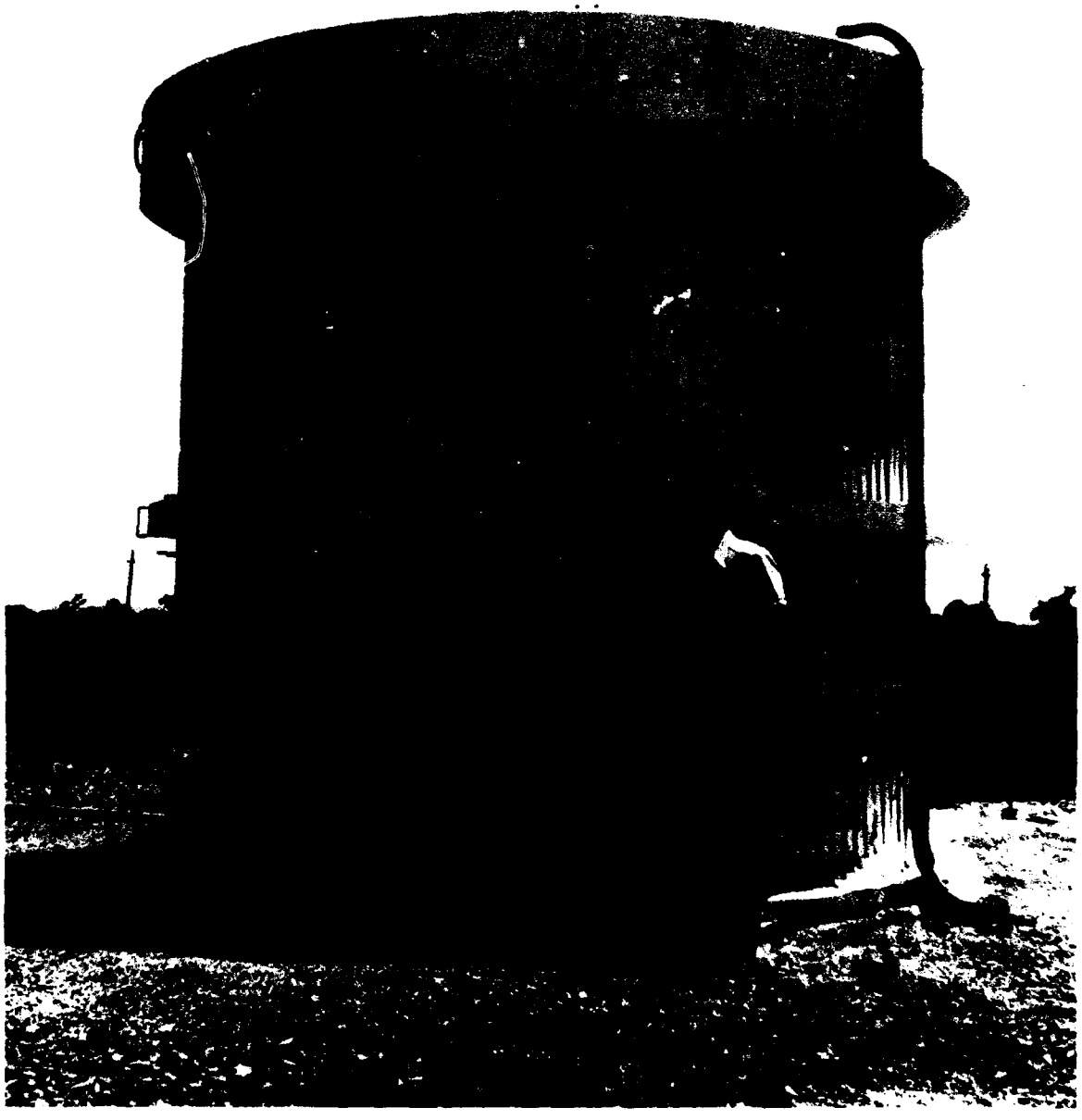

Figure 4. Grenade Loading Shield

I-BEAM CONFIGURATION SHOWING OPTIONAL ADDITION OF CLOSURE STRIPS AND DOUBLE LINER

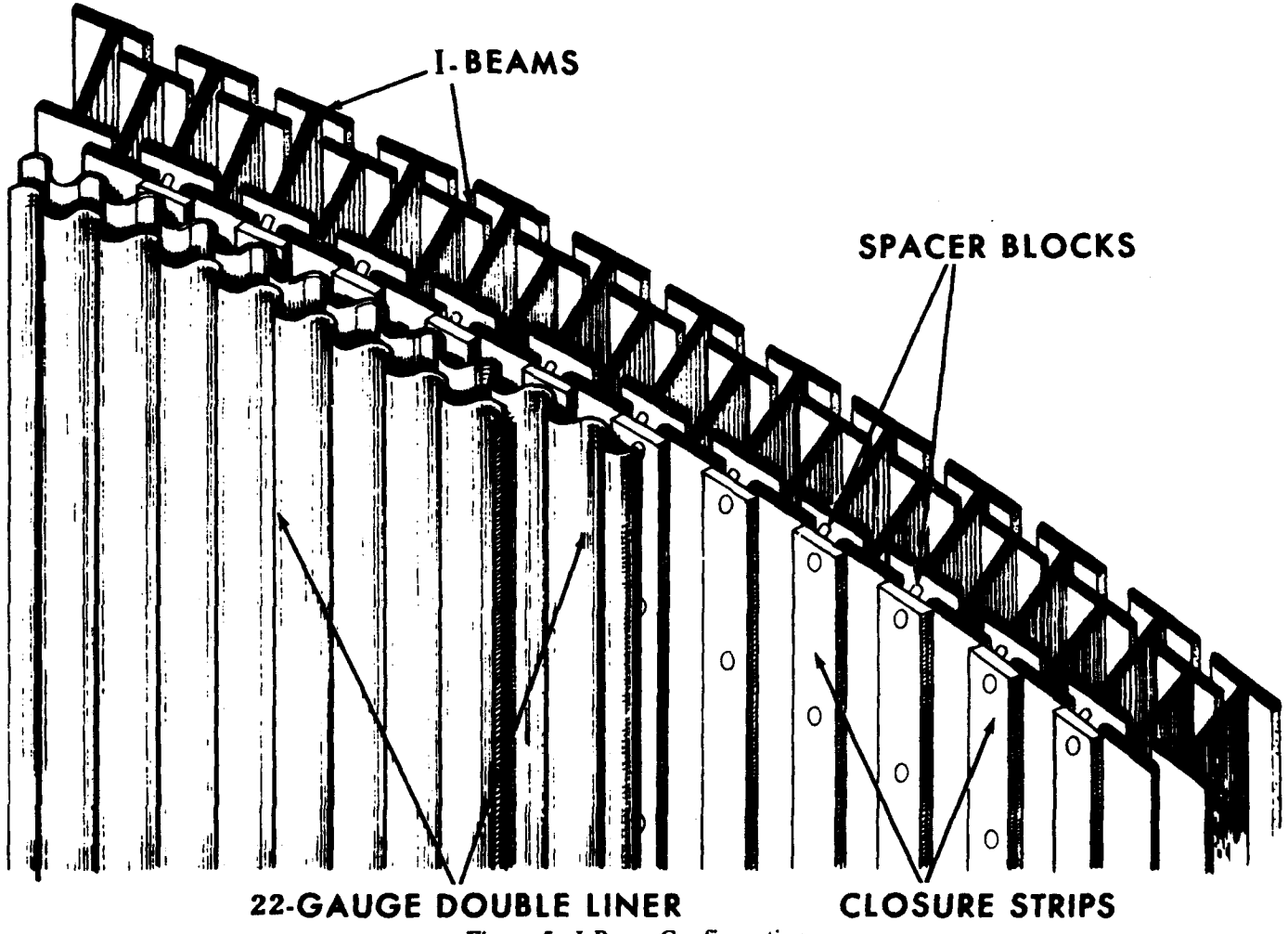

Figure 5. I-Beam Configuration

Surrounding the grenade loading operation would be an existing safety approved shield. This shield is similar in every respect to the screening building shield which is shown in figures 4 and 5. The grenade loading shield, which would be approximately 13 feet high by 13 feet in diameter, has been tested with 45.7 pounds of explosive and has an estimated cost of $56,316. This and all subsequent shields described limit the effects of an accidental explosion to an acceptable level.

Shielding the grenade swaging area would be a rectangular structure consisting of I-beams configured as shown in figure 6 to take the load from the blast effects of a 15-pound explosion. I-beam frames are constructed and placed adjacent to each other to form a box. Vertical beams are added at each end to enclose the shield. End beams and side beams are added to hold the ends on the shield and the I-beam frames in place in case of an explosion. A steel sheet internal liner would be added to improve blast pressure suppression. The shield would be 10 by 16 by 10 feet and would cost approximately $21,852.

The fuze-to-grenade assembly area is shielded by an I-beam shield very similar in design to the grenade swaging area shield. This shield, however, is larger (20 by 20 by 10 feet); but, because of the lower charge weight (8 pounds), it would be of lighter construction and would cost $31,780.

The first suppressive shield layout incorporates shields at all four locations previously described, as shown in figure 7. The following list of facts was used in designing this layout:

1. Overpressures from an explosion in a suppressive screening building are reduced sufficiently so that no damage will result to the other screening building if the two buildings are placed side by side.

2. Overpressures from an explosion in a screening building are reduced so that no structural damage will result to other buildings 10 feet from the screening buildings.

3. Calculations made by the US Army Corps of Engineers, Huntsville, Alabama, indicate that the screening buildings are strong enough to act as a barricade for the 10,000 pounds in the receiving building if they are placed within 40 feet of the receiving building. (Requirements for barricades are described in AMC Regulation 385-100.[3]) In this way, barricaded intraline distance can be used between the receiving and the loading, assembling, and packing buildings instead of unbarricaded intraline distance, thus cutting the conveyor lengths in half.

4. The effects of an explosion in the grenade loading operation, the grenade swaging operation, or the fuze-to-grenade assembly operation would be limited to one small area. Thus, five-sixths production (five of six grenade loading or swaging machines would remain in operation) could always be maintained. The less expensive one-building design could then be used and have all the advantages of the two-building layout.

5. The loading, assembling, and packing building used could be an inexpensive preengineered-type steel frame building because overpressures from an explosion in the loading, assembling, and packing building would be greatly reduced. The hardened concrete-type loading, assembling, and packing building presently required for all the Picatinny Arsenal design alternatives would be unnecessary to survive any accident in the building. Detailed costs of suppressive shield loading, assembling, and packing building are in table 1.

[3] AMC Regulation 385-100. Safety; Safety Manual. April 1970.

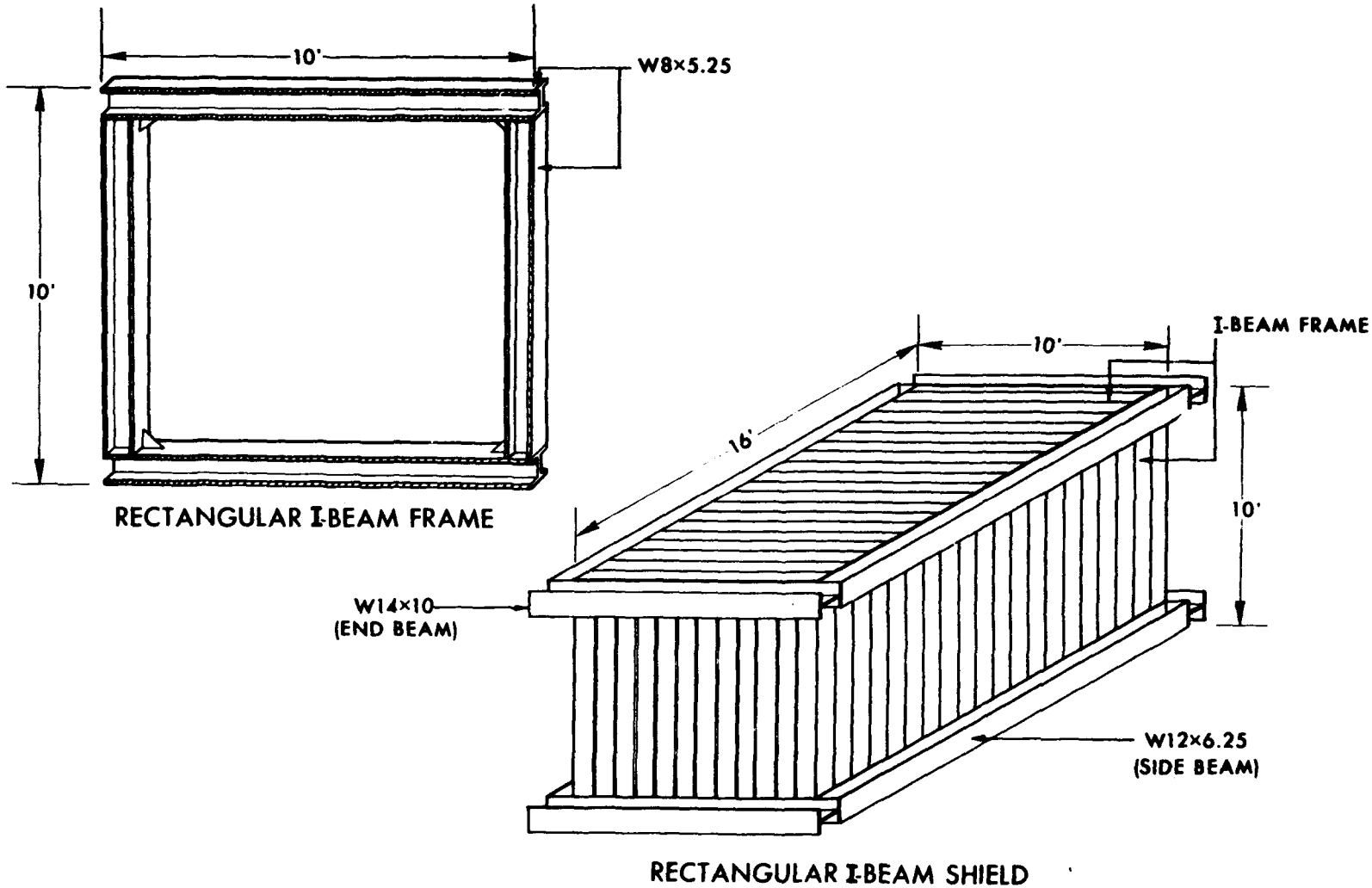

Figure 6. Rectangular I-Beam Shield and Frame

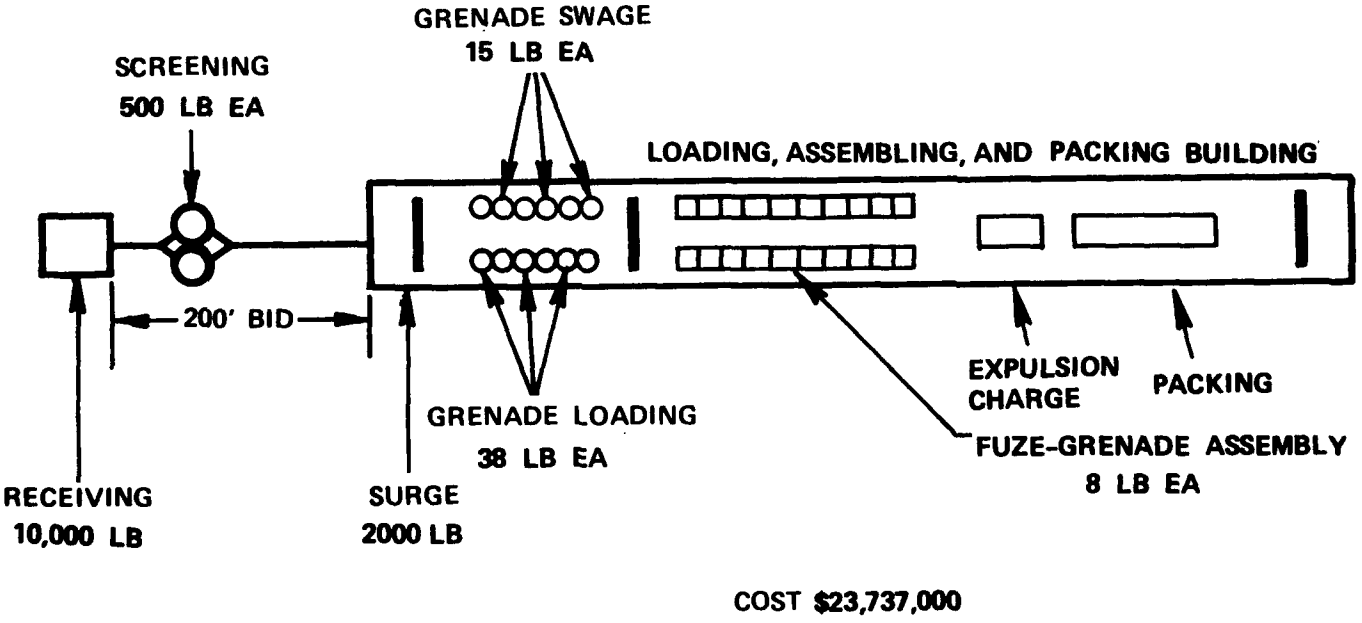

Figure 7. Suppressive Shield Alternative 1

Table 1. Suppressive Shielding Loading, Assembling, and Packing Building Cost Estimation

Item	Cost
Foundation concrete	$ 269,800
Floor slab concrete	214,200
Compacted fill	72,400
Aggregate under slab	27,100
Acoustical ceiling	3,800
Vinyl floor tile	2,600
Ceramic floor tile	1,600
Doors, 3 by 7 feet	34,700
Rollup doors, 16 by 12 feet	30,700
Rubber doors	3,000
Vault doors	19,500
Plumbing	30,000
Heating, ventilation, and air conditioning Mechanical fire protection	1,581,000
Electrical building	720,000
Building lighting	292,500
Communications	24,400
Roof insulation	58,500
Insulated wall panels	149,200
Building ($5.29/sq ft)*	449,000
	$3,984,000

* US Army Corps of Engineers, Huntsville Division. HNDTR-75-23-ED-SR. Overpressure Effects on Structures. Prepared for AMC Project Manager for Munitions Production Base Modernization and Expansion. 1 February 1976.

Cost reductions would be obtained from this alternative by reducing the conveyor lengths from the receiving building to the screening building and from the screening building to the loading, assembling, and packing building. Savings would also result because only one loading, assembling, and packing building instead of two is required to guarantee survivability and this building could be of a less-expensive construction. Conveyor cost in the loading, assembling, and packing building would be reduced from that of the two-building design to that of the one-building design.

Higher costs would result from the increased cost of the screening buildings and the increased cost of the shields at the grenade loading, swaging, and assembly areas.

Two designs using suppressive shielding were evaluated in detail. Suppressive shield alternative 1 is shown in figure 7. In this design, two screening buildings and one loading, assembling, and packing building are used to guarantee production. The two screening buildings are used as barricades on the 10,000-pound receiving building, thus reducing the distance from the receiving building to the loading, assembling, and packing building to the barricaded intraline distance of 200 feet. This alternative costs $23,736,568, resulting in a savings of $710,432 compared to the one-building design and $4,250,432 compared to the two-building design. Detailed cost data are summarized in table 2.

Suppressive shield alternative 2 (figure 8) is very similar to alternative 1 except no shield surrounds the screening operation. No conveyor lengths are reduced from receiving to screening buildings or from screening to loading, assembling, and packing buildings because the screening buildings are not used as barricades. In fact, conveyor lengths are doubled because conveyors must run to each of the two screening buildings. The cost of the second screening building adds $144,000. The shield costs in the loading, assembling, and packing building still increase by the same amounts and the loading, assembling, and packing building costs are the same as those in the alternative 1 layout. Alternative 2 costs $23,395,608 (table 3) which saves $1,051,392 compared to the one-building design cost and $4,591,309 compared to the two-building design cost.

IV. CONCLUSIONS.

Suppressive shield alternative 2 is the most cost effective layout using suppressive shields. This alternative maximizes safety for employees in the loading, assembling, and packing area because the shields here completely contain all fragments and reduce overpressures to an operator safe level in the immediate proximity of the shield. Production is guaranteed at five-sixths the full production rate if an accident occurs at one of the three areas in the loading, assembling, and packing building or at one-half the full production rate if an incident occurs in the screening building.

The initial cost of the facility is $23,395,608, which is $4,591,309 less than the two-building layout whose 50-percent production rate guarantee it exceeds. It is also more cost effective than the less desirable one-building layout by $1,051,392. The cost of the shielded screening building is too high to be offset by savings from reduced conveyor lengths and therefore the building should not be developed.

In addition to the cost savings itemized above, the use of suppressive shields in place of concrete cubicles allows greater flexibility in the loading, assembling, and packing building layout. Should a revised layout be required in the future, the suppressive shields may be moved about but the concrete cubicles would be unusable.

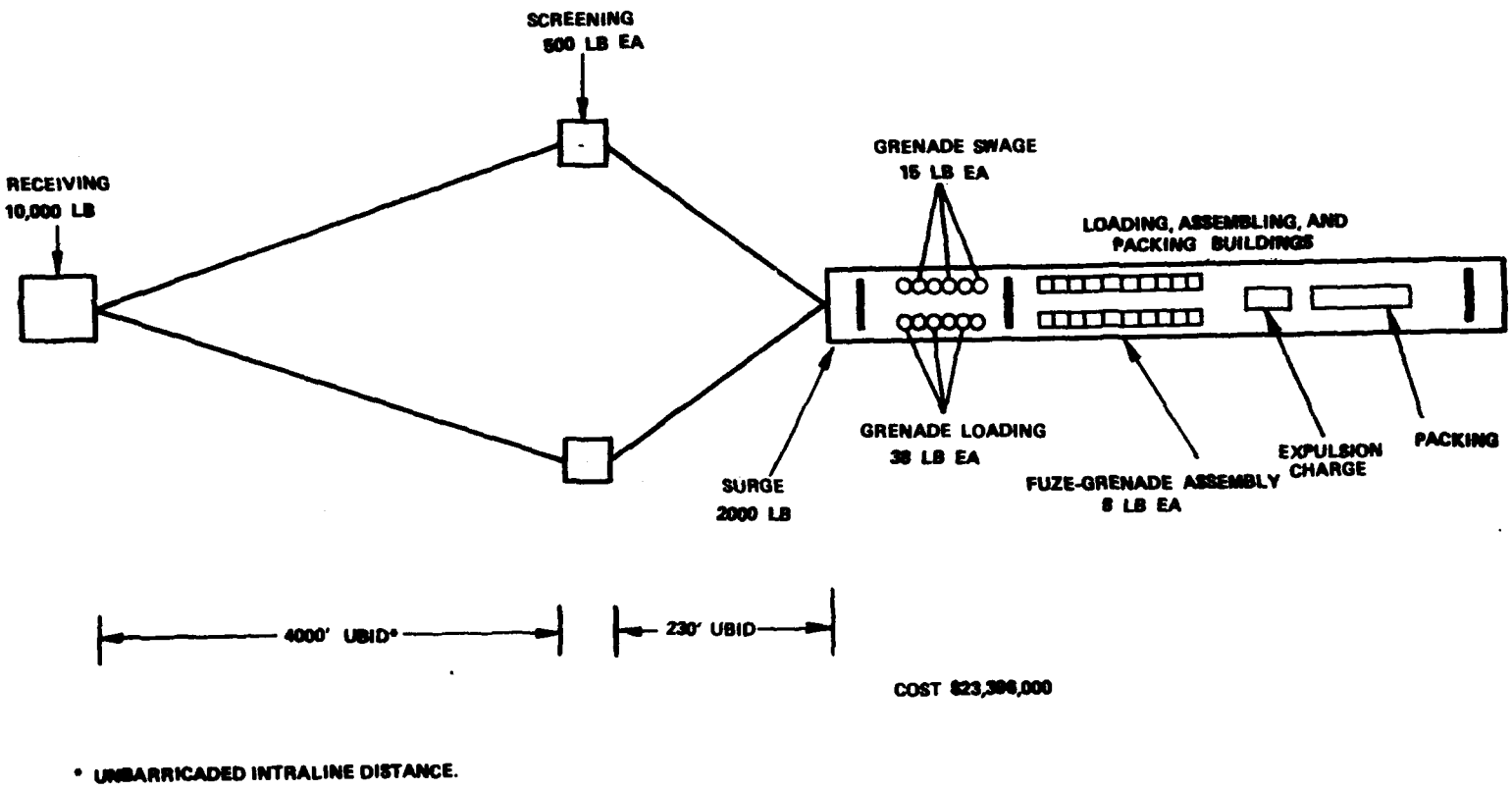

Figure 8. Suppressive Shield Alternative 2

Table 2. Cost Summary for Suppressive Shield Alternative 1

Item	Cost	Cost saving
One-building design cost (appendix A)	$24,447,000	
Screening building		
Two suppressive shields – $439,830 per shield	879,660	
Original screening building	144,000	
		($735,660)
Grenade press loading (six shields)		
$56,316 per suppressive shield	337,896	
$13,600 per original cubicle	81,600	
		($256,896)
Grenade swage (six shields)		
$21,852 per suppressive shield	131,112	
$10,500 per original cubicle	63,000	
		($68,112)
Fuze-to-grenade assembly (20 shields)		
$31,780 per suppressive shield	635,600	
$15,100 per original shield	302,000	
		($333,600)
Conveyors		
Receiving to screening – 350 feet at $670 per foot		$234,500
Screening to loading, assembling, and packing – 90 feet at $180 per foot		$16,200
Loading, assembling, and packing building		
Original loading, assembling, and packing building (appendix A)	5,838,000	
Preengineered loading, assembling, and packing building (table 1)	3,984,000	
		$1,854,000
Cost of suppressive shield alternative 1	$23,736,568	
Suppressive shield alternative 1 versus one-building design		$ 710,432
Suppressive shield alternative 1 versus two-building design		$ 4,250,432

Table 3. Cost Summary for Suppressive Shield Alternative 2

Item	Cost	Cost saving
One-building design cost (appendix A)	$24,447,000	
Screening building		
One additional building		($144,000)
Grenade press loading (six shields)		
$56,316 per suppressive shield	337,896	
$13,600 per original cubicle	81,600	
		($256,896)
Grenade swage (six shields)		
$21,852 per suppressive shield	131,112	
$10,500 per original cubicle	63,000	
		($68,112)
Fuze-to-grenade assembly (20 shields)		
$31,780 per suppressive shield	635,600	
$15,100 per original shield	302,000	
		($333,600)
Loading, assembling, and packing building		
Original loading, assembling, and packing building (appendix A)	5,838,000	
Preengineered loading, assembling, and packing building (table 1)	3,984,000	
		$1,854,000
Cost of suppressive shield alternative 2	$23,395,608	
Suppressive shield alternative 2 versus one-building design		$1,051,392
Suppressive shield alternative 2 versus two-building design		$4,591,309

V. RECOMMENDATIONS.

This analysis indicates a substantial cost savings by applying suppressive shielding technology to the M483A1 ICM loading, assembling, and packing facility. The magnitude of the cost reductions possible while maintaining production and safety guarantees warrants that suppressive shields be used on the ICM loading, assembling, and packing facility. An in-depth analysis of other new facilities is recommended to determine the cost effectiveness of applying suppressive shielding technology.

APPENDIX A

COST ESTIMATES OF LOADING, ASSEMBLING, AND PACKING LAYOUTS

U.S. ARMY ENGINEER DIVISION HUNTSVILLE
CORPS OF ENGINEERS
HUNTSVILLE, ALABAMA

PRELIMINARY COST ESTIMATE | DATE PREPARED: REVISED 3/23/75 | SHEET 1 OF 1

PROJECT: 155 MM ICM LAP AREA

LOCATION: MISSISSIPPI ARMY AMMUNITION PLANT

ARCHITECT ENGINEER: KAISER ENGINEERS | CWE | PROGRAMMED

LINE ITEM NO. OR CAT. CODE NO. | ESTIMATOR: J. D. BROWN | CHECKED BY: SEB | APPVD. BY

ITEM NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	LAP AREA ONE-BUILDING CONFIGURATION				
	LAP BUILDING	84,882	SF		$ 5,838,000
	BULK EXPLOSIVE BLDG.	3,750	SF		199,000
	SCREENING BUILDING	3,000	SF		144,000
	BODY LOADING & HOLD BLDG	3,300	SF		160,000
	GRENADE HOLDING IGLOOS 6ea	20,160	SF		939,000
	SHIPPING BUILDING	4,400	SF		96,000
	EXPULSION CHARGE BLDG.	1,800	SF		95,000
	CHEMICAL LAB BLDG.	2,500	SF		148,000
	X RAY BUILDING	2,000	SF		106,000
	DEMIL. BUILDING	4,900	SF		237,000
	OFFICE, CHANGE RM, CAFETERIA	21,664	SF		785,000
	COVERED RAMPS	33,060	SF		886,000
	CONCRETE PAVING	56,150	SF		67,000
	ASPHALT PAVING	485,000	SF		315,000
	SHELL PAVING	13,500	SF		5,000
	FENCE	7,500	LF		60,000
	RAILROAD	5,805	LF		290,000
	YARD ELECTRICAL	1-Job	—		315,000
	YARD UTILITIES	1-Job	—		1,026,000
	GUARD HOUSE (GATE)	80	SF		3,000
	TOTAL DIRECT COST				11,714,000
	INDIRECT COSTS & ADDITIVES			108.7%	12,733,000
	TOTAL PROJECT COST SINGLE BUILDING CONCEPT				$24,447,000

HND Form 8
4 MAR 68

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U.S. ARMY ENGINEER DIVISION HUNTSVILLE
CORPS OF ENGINEERS
HUNTSVILLE, ALABAMA

PRELIMINARY COST ESTIMATE | DATE PREPARED: REVISED 2/13/76 | SHEET 1 OF 1

PROJECT: 155 MM ICM LAP AREA

LOCATION: MISSISSIPPI ARMY AMMUNITION PLANT

ARCHITECT ENGINEER: KAISER ENGINEERS | CWE | PROGRAMMED

LINE ITEM NO. OR CAT. CODE NO. | ESTIMATOR: J. D. BROWN | CHECKED BY: S E B | APPVD. BY

ITEM NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	LAP AREA TWO BUILDING CONFIGURATION				
	LAP BUILDINGS 2 EA.	97,440	SF		$ 6,890,000
	BULK EXPLOSIVE BLDG.	3,750	SF		199,000
	SCREENING BLDG. 2 EA.	3,000	SF		144,000
	BODY LOADING HOLD 2 EA.	3,300	SF		160,000
	GRENADE HOLD IGLOOS 6 EA	20,160	SF		939,000
	SHIPPING BUILDING	4,400	SF		96,000
	EXPULSION CHG. BLDG	1,800	SF		95,000
	CHEMICAL LAB BLDG.	2,500	SF		148,000
	X-RAY BUILDING	2,000	SF		106,000
	DEMIL. BUILDING	4,900	SF		237,000
	OFFICE, CHANGE RM, CAFETERIA	21,664	SF		785,000
	COVERED RAMPS	45,000	SF		1,206,000
	CONCRETE PAVING	52,000	SF		62,000
	ASPHALT PAVING	565,000	SF		367,000
	SHELL PAVING	13,500	SF		5,000
	FENCE	7500	LF		60,000
	RAILROAD	6900	LF		345,000
	YARD ELECTRICAL	1-Job			446,000
	YARD UTILITIES	1-Job			1,117,000
	GUARD HOUSE (GATE)	80	SF		3,000
	TOTAL DIRECT COST				13,410,000
	INDIRECT COSTS & ADDITIVES			108.7%	14,577,000
	TOTAL PROJECT COST TWO BUILDING CONCEPT				$27,987,000

HND Form 6
4 MAR 68

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U.S. ARMY ENGINEER DIVISION HUNTSVILLE
CORPS OF ENGINEERS
HUNTSVILLE, ALABAMA

PRELIMINARY COST ESTIMATE | DATE PREPARED: REVISED 2/13/76 | SHEET 1 OF 1

PROJECT: 155 MM ICM LAP AREA

LOCATION: MISSISSIPPI ARMY AMMUNITION PLANT

ARCHITECT ENGINEER: KAISER ENGINEERS | CWE | PROGRAMMED

LINE ITEM NO. OR CAT. CODE NO. | ESTIMATOR: J. D. BROWN | CHECKED BY: S F B | APPVD. BY

ITEM NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	LAP AREA THREE BUILDING CONFIGURATION				
	GRENADE ASSEMBLY	30,100	SF		$ 2,444,000
	BODY LOADING BLDG.	30,100	SF		1,957,000
	ASSEMBLY & SURGE BLDG.	35,700	SF		1,971,000
	BULK EXPLOSIVES BLDG.	3,750	SF		199,000
	SCREENING BLDG.	3,000	SF		144,000
	BODY LOADING HOLD BLDG	3,300	SF		160,000
	GRENADE HOLD IGLOOS 6 EA.	20,160	SF		939,000
	SHIPPING BUILDING	4400	SF		96,000
	EXPULSION CHG. BLDG.	1800	SF		95,000
	CHEMICAL LAB BLDG.	2500	SF		148,000
	X-RAY BUILDING	2000	SF		106,000
	DEMIL BUILDING	4900	SF		785,000
	OFFICE, CHANGE RM, CAFETERIA	21,664	SF		237,000
	COVERED RAMPS	40,200	SF		1,077,000
	CONCRETE PAVING	61,900	SF		74,000
	ASPHALT PAVING	23,8000	SF		148,000
	SHELL PAVING	33,000	SF		13,000
	FENCE	7700	LF		62,000
	RAILROAD	5665	LF		283,000
	YARD ELECTRICAL	1-Job			327,000
	YARD UTILITIES	1-Job			1,079,000
	GUARD HOUSE (GATE)	80	SF		3,000
	TOTAL DIRECT COST				12,347,000
	INDIRECT COST AND ADDITIVES			108.7%	13,421,000
	TOTAL PROJECT COST				
	3 BUILDING CONCEPT				$ 25,768,000

HND Form 8
4 MAR 68

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APPENDIX B

COST ESTIMATES OF SUPPRESSIVE SHIELDS

CONSTRUCTION COST ESTIMATE	DATE PREPARED 6 APR 76	SHEET 1 OF 3
PROJECT: GRENADE PRESS LOADING	BASIS FOR ESTIMATE: ☐ CODE A (No design completed) ☐ CODE B (Preliminary design) ☐ CODE C (Final design) ☒ OTHER (Specify) STUDY	
LOCATION: MISSISSIPPI AAP		
ARCHITECT ENGINEER: HND (E. WILLIAMS, ED-CH)		
DRAWING NO.: 6000 THRU 6004	ESTIMATOR: DT	CHECKED BY: CRJ

SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR PER UNIT	LABOR TOTAL	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
SHEET 2				1764		5399	7163
SHEET 3				24813		9521	34334
TOTAL DIRECT COST				26577		14920	41497
O'HEAD ON LABOR	15%			3987		—	3987
SALES TAX ON MATLS	4%			—		597	597
SUBTOTAL				30564		15517	46081
O'HEAD	10%						4608
SUBTOTAL							50689
PROFIT	10%						5069
SUBTOTAL							55758
BOND	1%						558
CONSTRUCTION COST							$56 316

CONSTRUCTION COST ESTIMATE	DATE PREPARED 6 APR 76	SHEET 2 OF 3
PROJECT: GRENADE PRESS LOADING	BASIS FOR ESTIMATE: ☐ CODE A (No design completed) ☐ CODE B (Preliminary design) ☐ CODE C (Final design) ☒ OTHER (Specify) STUDY	
LOCATION: MISSISSIPPI AAP		
ARCHITECT ENGINEER: HND (E. WILLIAMS, ED-CH)		
DRAWING NO.: 6000 THRU 6004	ESTIMATOR: DT	CHECKED BY: CRJ

SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR PER UNIT	LABOR TOTAL	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
CONCRETE (ROOF & FDN) (5000 PSI)	16	Yd^3	20.00	320	32.00	512	832
REINFORCING (ROOF & FDN) (FY = 60,000 PSI)							
#4 BARS (MAIN REIN)	3	T	200.00	600	300.00	900	1500
#4 STIRRUPS	2	T	200.00	400	300.00	600	1000
PIPE SLEEVES (ASTM-A53) FOR A.B. (ROOF & FDN)							
3/4" Ø SCH 40 PIPE X 1.5' LG	.5	T	W/CAGE ASSM.		400.00	200	200
EMBEDDED PLATE (ASTM A-36) IN CONC. (ROOF & FDN.)	1.1	T	"	"	400.00	440	440
ANCHOR BOLTS (ROOF & FDN) ASTM A 325							
3/4" Ø X 20" LG W/NUT & 2 WASHERS	592	EA.	0.75	444	2.90	1717	2161
STEEL FIBERS 200 #/Yd^3	1.6	T	W/CAGE ASSM.		400.00	640	640
FRAGMENT SHIELD (ASTM A-36) ON ROOF	.2	T		"	400.00	80	80
A.B. FOR FRAGMENT SHIELD 5" ASTM A-307	46	EA.		"	5.00	230	230
LIFTING LUGS (ASTM A36)	.2	T		"	400.00	80	80
THIS SHEET				1764		5399	7163

CONSTRUCTION COST ESTIMATE

DATE PREPARED: 6 APR 76 | SHEET 3 OF 3

PROJECT: GRENADE PRESS LOADING

LOCATION: MISSISSIPPI AAP

ARCHITECT ENGINEER: HND (E. WILLIAMS, ED-CH)

BASIS FOR ESTIMATE:
- ☐ CODE A (No design completed)
- ☐ CODE B (Preliminary design)
- ☐ CODE C (Final design)
- ☒ OTHER (Specify) STUDY

DRAWING NO.: 6006 thru 6004

ESTIMATOR: DT

CHECKED BY: CRJ

SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR PER UNIT	LABOR TOTAL	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
EXCAVATION, MACH	17.5	Yd^3	–	–	2.50	44	44
SAND LEVELING COURSE	3.5	Yd^3	5.50	19	5.00	18	37
BACK FILL	8	Yd^3	5.50	44	–	–	44
CAGE (ASTM A-36)							
I-BMS	8.5	T					
GUSSETS FOR I-BMS	.75	T					
BASE PL. FOR I-BMS	1	T					
CLOSURE STRIPS	1	T					
RING BMS	2.2	T					
DOOR FRAME	.2	T					
DOOR	.3	T					
BOLTS FOR DOOR 3/4"X4½LG	4	EA					
TOTAL STEEL	18	TONS	↓	–	400.00	7200	7200
LABOR REQ'D TO CUT STEEL & ASSM. CAGE	2800	MH	8.50	23800		–	23800
EDGE FORMS FDN & TOP	125	SF	4.00	500	2.50	312	812
PAINT CAGE W/PRIMER & 1 COAT PAINT	18	CAGES	25.00	450	15.00	270	720
CONSUMABLE ITEMS	4300	LBS	–	–	0.39	1677	1677
THIS SHEET				24813		9521	34334

* U.S. GOVERNMENT PRINTING OFFICE 1980 O—310148

CONSTRUCTION COST ESTIMATE

DATE PREPARED: 13 MAY 76 | SHEET 1 OF 3

PROJECT: SUPPRESSIVE SHIELD SCREENING BLDG

LOCATION: MISSISSIPPI AAP

ARCHITECT ENGINEER: EWA K.P. NELSON (SARFA-MT-TS)

BASIS FOR ESTIMATE
- ☐ CODE A (No design completed)
- ☐ CODE B (Preliminary design)
- ☐ CODE C (Final design)
- ☒ OTHER (Specify) STUDY

DRAWING NO.

ESTIMATOR: KPN

CHECKED BY: [illegible]

SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR PER UNIT	LABOR TOTAL	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
SHEET 2				19536		56410	75946
SHEET 3				148068		104313	252381
TOTAL DIRECT COST				167604		160723	328327
O'HEAD ON LABOR 15%				25140		—	25140
SALES TAX ON MTLS 4%				—		6429	6429
SUBTOTAL				192744		167152	359896
O'HEAD 10%							35990
SUBTOTAL							395886
PROFIT 10%							39589
SUBTOTAL							435475
BOND 1%							4355
CONSTRUCTION COST							$439,830

* U.S. GOVERNMENT PRINTING OFFICE 1980 0—816160

CONSTRUCTION COST ESTIMATE	DATE PREPARED 13 MAY 76	SHEET 2 OF 3

PROJECT: SUPPRESSIVE SHIELD SCREENING BLDG
LOCATION: MISSISSIPPI AAP
ARCHITECT ENGINEER: EWA K.P. NELSON (SARE A-AT-TS)

BASIS FOR ESTIMATE
- ☐ CODE A (No design completed)
- ☐ CODE B (Preliminary design)
- ☐ CODE C (Final design)
- ☒ OTHER (Specify) STUDY

DRAWING NO.
ESTIMATOR: KPN
CHECKED BY: [illegible]

SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR PER UNIT	LABOR TOTAL	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
CONCRETE (ROOF & FDN)	225	Yd³	20.00	4500	32.00	7200	11700
(5000 PSI)							
REINFORCING (ROOF & FDN)							
#4 BARS (MAIN REINF)	42	T	200.00	8400	300.00	12600	21000
#4 STIRRUPS	28	T	200.00	5600	300.00	8400	14000
PIPE SLEEVES (ASTM-A53)							
FOR A.B. (ROOF & FDN)							
1.8"Ø SCH 40 PIPE X 3.6'LG	1.5	T	W/CAGE ASSM.		400.00	600	600
EMBEDDED PLATE							
IN CONC. (ROOF & FDN.	15	T	"	"	400.00	6000	6000
ANCHOR BOLTS (ROOF & FDN)	592	EA.	1.75	1036	16.70	9888	10924
1.8"Ø X 4' LG							
W/NUT & 2 WASHERS							
STEEL FIBERS	22.5	T	W/CAGE ASSM.		400.00	9000	9000
200#/Yd³							
FRAGMENT SHIELD	2.75	T	"	"	400.00	1100	1100
ON ROOF (A-36)							
A.B. FOR FRAG SHIELD	46	EA.	"	"	12.00	522	522
ASTM A 307							
LIFTING LUGS	2.75	T	"	"	400.00	1100	1100
THIS SHEET				19536 ~~18600~~		56410	75946

CONSTRUCTION COST ESTIMATE	DATE PREPARED 13 MAY 76	SHEET 3 OF 3

PROJECT: SUPPRESSIVE SHIELD SCREENING BLDG.
LOCATION: MISSISSIPPI AAP
ARCHITECT ENGINEER: EWA K.P. NELSON (SAREA-MT-TS)

BASIS FOR ESTIMATE
- ☐ CODE A (No design completed)
- ☐ CODE B (Preliminary design)
- ☐ CODE C (Final design)
- ☒ OTHER (Specify) STUDY

DRAWING NO.
ESTIMATOR: KPN
CHECKED BY: GRF

SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR PER UNIT	LABOR TOTAL	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
EXCAVATION, MACH.	245	Yd3	—	—	2.50	613	613
SAND LEVELING, COARSE	50	Yd3	5.50	275	5.00	250	525
BACK FILL	115	Yd3	5.50	633	—	—	633
CAGE (ASTM A-36)							
I-BMS (W8 28)	107	T					
GUSSETS FOR I-BMS	9.5	T					
BASE PLs FOR I-BMS	13	T					
CLOSURE STRIPS	12.5	T					
RING BMS	27.5	T					
DOOR FRAME	3	T					
DOOR	3	T					
BOLTS	10	T					
Total Steel	185.5	TONS		—	400.00	74200	74200
LABOR REQ'D TO CUT STEEL & ASSEMBLE CAGE	16200	MH	8.50	137,700	—	—	137700
EDGE FORMS F'DN & TOP	1740	SF	4.00	6960	2.50	4350	11310
PAINT CAGE w/PRIMER & 1 COAT PAINT	100	GLS	25.00	2500	15.00	1500	4000
CONSUMABLE ITEMS	60000	LBS	—	—	0.39	23400	23400
THIS SHEET				148068		104313	252381

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CONSTRUCTION COST ESTIMATE

DATE PREPARED: 14 MAY 76 | SHEET 1 OF 2

PROJECT: SUPPRESSIVE SHIELD GRENADE SWAGE

LOCATION: MISSISSIPPI AAP

ARCHITECT ENGINEER: EWA K. P. NELSON (SAREA-MT-TS)

BASIS FOR ESTIMATE:
- ☐ CODE A (No design completed)
- ☐ CODE B (Preliminary design)
- ☐ CODE C (Final design)
- ☒ OTHER (Specify) STUDY

DRAWING NO.:

ESTIMATOR: KPN

CHECKED BY:

SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR PER UNIT	LABOR TOTAL	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
TOTAL DIRECT COST (SHEET 2)				6325		10199	16524
O'HEAD ON LABOR	15%			949		—	949
SALES TAX ON MATLS	4%			—		408	408
SUBTOTAL				7274		10607	17881
O'HEAD	10%						1788
SUBTOTAL							19669
PROFIT	10%						1967
SUBTOTAL							21636
BOND	1%						216
CONSTRUCTION COST							$21852

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CONSTRUCTION COST ESTIMATE	DATE PREPARED 14 MAY 76	SHEET 2 OF 2

PROJECT: SUPPRESSIVE SHIELD GRENADE SLWAGE

LOCATION: MISSISSIPPI AAP

ARCHITECT ENGINEER: EWA K.P. NELSON (SAREA-MT-TS)

BASIS FOR ESTIMATE: ☐ CODE A (No design completed) ☐ CODE B (Preliminary design) ☐ CODE C (Final design) ☒ OTHER (Specify) STUDY

DRAWING NO.

ESTIMATOR: KPN

CHECKED BY: [illegible]

SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR PER UNIT	LABOR TOTAL	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
I-BMS							
(W8X5.25) TOP, SIDES, FLOOR, ENDS	14	T					
(W14X10) END BMS	1.5	T					
(W12X6.25) SIDE BMS	4	T					
GUSSETS	.4	T					
1/16" LINER	1	T					
TOTAL STEEL	20.9	TONS	—	—	400.00	8360	8360
LABOR REQ'D TO CUT & ASSM. STEEL	700	MH	8.50	5950	—	—	5950
BOLTS (½" Ø X 3")	296	EA	—	—	0.18	54	54
PAINT W/PRIMER & 1 COAT PAINT	15	GALS	25.00	375	15.00	225	600
CONSUMABLE ITEMS	4000	LBS	—	—	0.39	1560	1560
TOTAL DIRECT COST				6325		10199	16524

CONSTRUCTION COST ESTIMATE

DATE PREPARED: 14 MAY 76 | SHEET 1 OF 2

PROJECT: FUZE TO GRENADE ASSEMBLY

LOCATION: MISSISSIPPI AAP

ARCHITECT ENGINEER: EWA K.P. NELSON (SAREA-MT-TS)

BASIS FOR ESTIMATE:
- ☐ CODE A (No design completed)
- ☐ CODE B (Preliminary design)
- ☐ CODE C (Final design)
- ☒ OTHER (Specify) STUDY

DRAWING NO.:

ESTIMATOR: KPN

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SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR PER UNIT	LABOR TOTAL	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
TOTAL DIRECT COST (SHEET 2)				8200		15937	24137
O'HEAD ON LABOR	15%			1230			1230
SALES TAX ON MTL'S	4%					638	638
SUBTOTAL				9430		16575	26005
O'HEAD	10%						2600
SUBTOTAL							28605
PROFIT	10%						2860
SUBTOTAL							31465
BOND	1%						315
CONSTRUCTION COST							$ 31780

CONSTRUCTION COST ESTIMATE	DATE PREPARED 14 MAY 76	SHEET 2 OF 2

PROJECT: FUZE TO GRENADE ASSEMBLY
LOCATION: MISSISSIPPI AAP
ARCHITECT ENGINEER: EWA K. P. NELSON (SAREA-MT-TS)

BASIS FOR ESTIMATE
- ☐ CODE A (No design completed)
- ☐ CODE B (Preliminary design)
- ☐ CODE C (Final design)
- ☒ OTHER (Specify) STUDY

DRAWING NO.
ESTIMATOR: KPN
CHECKED BY: [illegible]

SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR PER UNIT	LABOR TOTAL	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
I-BMS (W8X5.25) SIDES, TOP BOTTOM, ENDS	26	T					
(W8X6.25) SIDE BMS.	1	T					
(W14X12) END BMS.	3.5	T					
GUSSETS	.4	T					
1/16" LINER	2.1	T					
TOTAL STEEL	33	TONS	—	—	400.00	13200	13200
LABOR REQ'D TO CUT & ASSM. STEEL	900	MH	8.50	7650			7650
BOLTS (½" Ø X 3")	368	EA	—	—	0.18	67	67
PAINT W/PRIMER & 1 COAT PAINT	22	GALS	25.00	550	15.00	330	880
CONSUMABLE ITEMS	6000	LBS	—	—	0.39	2340	2340
TOTAL DIRECT COST				8200		15937	24137

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